Introduction of the Streaked Goby *Acentrogobius pflaumii* (Bleeker 1853) (Pisces: Gobiidae) into southwestern Australia

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ABSTRACT

The gobiid, *Acentrogobius pflaumii*, was recorded in Cockburn Sound in southwestern Australia in 2004, and is now reported for the first time from the Swan River Estuary *ca*. 20 km north of the initial collection site. It was observed by SCUBA divers on open, soft/silt substrata and was abundant in areas of the middle Swan River Estuary. Ballast water emissions from a nearby international port, containing eggs and/or fish, are considered the most likely introductory vector. Although the ichthyofauna of the Swan River Estuary has been frequently surveyed, it is difficult to speculate how long *A. pflaumii* has occurred in southwestern Australia because most surveys have not targeted small, cryptic species. The population increase and spread of *A. pflaumii* in eastern Australia and New Zealand infer that further range expansions in southwestern Australia are likely.

Key words: *Arenigobius bifrenatus, Acentrogobius pflaumii*, ballast water, cryptic fishes, Gobiidae, introduced species, translocation

Introduction

There is increasing concern over the potential environmental and economic impacts caused by the worldwide, human-mediated translocation of marine organisms (Carlton and Gellar 1993; Lockett and Gomon 2001). Many marine organisms have been introduced to Australia (Hewitt *et al*. 2004), with invertebrates and algae the principle taxa (Lockett and Gomon 2001). Some successful invertebrate introductions, such as the European fan-worm (*Sabella spallanzanii*) and the North Pacific seastar (*Asterias amurensis*), have deleteriously impacted upon indigenous marine fauna and ecosystems (Sutton and Bruce 1996). In contrast to the large numbers of introduced marine invertebrates is the lack of self-sustaining populations of translocated marine fishes (Baltz 1991). Most introduced marine fishes are small, cryptic species from the families Gobiidae, Blenniidae and Eleotridae (Wonham *et al*. 2000). The release of ballast water from international bulk-cargo vessels containing eggs, post-larval or adult fishes is considered the main introductory vector (Carlton 1985; Hewitt *et al*. 2004, Hayes *et al*. 2005). Wonham *et al*. (2000) identified gobiids as the family of fishes most commonly found in ballast water, and also the most successfully established fishes from ballast water-mediated introductions.

The Streaked Goby, *Acentrogobius pflaumii*, (Fig. 1) is a small goby (maximum 80 mm) that is native to Japan, Korea, Taiwan and the Philippines (Fowler 1961; Masuda *et al*. 1984). Within this range it occurs on soft substrata, sand and seagrass beds in brackish estuarine waters and coastal embayments (Matsumiya *et al*. 1980;

Figure 1. Streaked Goby, *Acentrogobius pflaumii* (70 mm total length), photographed at Mosman Park in the Swan River Estuary on 6th March, 2005. (M. Maddern).

Kanou *et al*. 2004). *Acentrogobius pflaumii* has successfully invaded ports and harbours in other localities including Waitemata and Whangapoua Harbours in northeastern New Zealand, Botany Bay and Sydney Harbour in New South Wales (Francis *et al*. 2003) and Port Phillip Bay in Victoria (Lockett and Gomon 2001). It was first recorded in Australia in 1996 at the Victoria Docks in Port Phillip Bay (Lockett and Gomon 2001). Qualitative surveys undertaken throughout Port Phillip Bay in 1996-1997 revealed that *A. pflaumii* occurred in almost all areas of the bay and also in the lower estuary of the Yarra River (Hamer *et al.* 1998). *Acentrogobius pflaumii* was first reported in southwestern Australia from a single location in Cockburn Sound in 2004 (Mead-Hunter 2005). This paper reports the range expansion of *A. pflaumii* to include multiple sites in the Swan River Estuary approximately 20 km north of the initial collection site in Cockburn Sound. Also discussed are the potential ecological impacts of *A. pflaumi* and the benthic habitats colonised in these areas.

Methods

The Swan River Estuary (SRE) is microtidal and consists of three morphologically distinct sections (Bird 1984). The lower estuary is a narrow entrance channel of which the first three kilometres constitute the international port of Fremantle, while the middle estuary consists of two large, shallow basins. Sample sites were in the lower-middle SRE with comparable bathymetry and hydrological regimes. The Mediterranean climate of southwestern Australia results in highly seasonal precipitation, principally from May to September (Hoeksema and Potter 2006). Outside of these months the salinity of the lower and middle SRE approximates seawater (Gaughan *et al*. 1990; Potter and Hyndes 1999).

SCUBA divers conducted qualitative surveys noting the approximate depth and substrate composition when fish were observed. The behaviour of *Acentrogobius pflaumii* was not visibly influenced by the presence of SCUBA divers, as also noted by Horinouchi and Sano (2001). Voucher specimens are lodged at the Western Australian and Australian Museums. Photographs of *A. pflaumii* taken *in situ* were submitted to the FISHBASE online database (http://www.fishbase.org).

Results

During 2004, an unidentified gobiid was observed and photographed at Rockingham in Cockburn Sound (32°16.265' S, 115°43.810' E), and Point Walter (32°00.560' S, 115°47.280' E) and Bicton (32°01.195' S, 115°46.910' E) in the SRE. *Acentrogobius pflaumii* (Fig. 1) was identified from a specimen collected (20th December, 2004) at Point Walter on soft substrata near jetty pylons in water five metres deep. Surveying similar habitats in the lower-middle SRE revealed fish at Mosman Park (32°00.455' S, 115°46.378' E), East Fremantle (32°01.570' S, 115°46.205' E) and Claremont (31°59.415' S, 115°46.881' E).

Acentrogobius pflaumii was observed only on open, soft/silt substrata in water from five to twenty-two metres deep (i.e. the maximum depth of the SRE). Of the locations surveyed, *A. pflaumii* was abundant at Bicton and Mosman Park, particularly in eight to thirteen metres of water. It was not recorded on coarser, sand substrata. Within this habitat it occupied burrows co-occurring with an alpheid shrimp. *Acentrogobius pflaumii* was observed near the burrow entrance, while the burrow was excavated by the shrimp; behaviour also noted by Mead-Hunter (2005). Both animals would quickly retreat to the burrow if disturbed. Fish were from 40 to 80 mm total length, though the majority were in the range of 60 to 70 mm. No other goby species was observed occupying this habitat.

Discussion

Acentrogobius pflaumii inhabits open silt/mud substrata within its native range and as an introduced species in New Zealand (Francis *et al*. 2003) and Australia (Lockett and Gomon 2001; Mead-Hunter 2005). The occupation of burrows has been noted by Francis *et al*. (2003) in New Zealand and Western Australia (Mead-Hunter 2005; this study), though the co-habitation of burrows with alpheid shrimps has been observed only in Western Australia. It is unknown if these behaviours are widespread or occur only in introduced populations and/or particular environments. However, as these behavioural characteristics may be observed only by SCUBA divers *in situ*, it follows that they will, of course, be recorded only by studies utilising this sampling methodology.

Gobiids are one of the dominant ichthyofaunal families of temperate Australian estuaries (Potter and Hyndes 1999), and show distinct spatial segregation patterns in the SRE based on salinity tolerance, habitat, substrate and dietary preferences (Gill and Potter 1993). *Acentrogobius pflaumii* was the only gobiid observed occupying open silt substrata in water deeper than five metres. In shallow open substrata (i.e. less two metres) within the lower/middle SRE, *Favonigobius lateralis* is abundant with densities as high as *ca.* 200 fish per 100 m^2 (Gill and Potter 1993). In deeper areas, the native gobiid *Arenigobius bifrenatus* has been noted in past surveys (Hutchins and Thompson 1983; Gill and Potter 1993) though was not observed in this study. Otter trawls conducted by Gill and Potter (1993) in deeper areas of the SRE recorded few gobiids though the majority (i.e. *ca.* 90%) were *A. bifrenatus*. In New Zealand harbours, Francis *et al.* (2003) noted that both introduced *A. bifrentatus* and *A. pflaumii* occupied similar habitats, though were not recorded in close proximity nor collected in the same seine-net tow. Thus, while it is unknown if *A. bifrenatus* has occurred or still occurs in the exact areas where *A. pflaumii* now thrives in the SRE, it was not observed in this survey. Both gobiids occupy similar benthic environments and there is the potential for competition for habitat to occur between the introduced *A. pflaumii* and the native *A. bifrenatus* and possibly other native gobiids.

It is likely that *A. pflaumii* was introduced to this region by the release of ballast water and/or hull fouling from international bulk-cargo vessels, particularly as international ports are located in the lower SRE (Fremantle) and nearby Cockburn Sound. Furthermore, while this vector was considered responsible for its

introduction to Victoria and New Zealand (Lockett and Gomon 2001; Francis *et al*. 2003), it is however, difficult to speculate when this introduction to southwestern Australia occurred. Small, cryptic species are, by their very nature, difficult to observe and quantify. The ichthyofauna of the SRE has been regularly surveyed and described for at least three decades (e.g. Chubb *et al*. 1979; Hutchins and Thompson 1983; Loneragan *et al*. 1989; Gill and Potter 1993; Potter and Hyndes 1999; Hoeksema and Potter 2006) though *A. pflaumii* was not recorded. The techniques utilised for these surveys, mostly seine and gill nets in shallow areas (e.g. Gill and Potter 1993; Hoeksema and Potter 2006), and otter trawls in deeper areas (e.g. Potter and Hyndes 1999), were inappropriate for the collection of small, cryptic fishes. Such fishes are commonly surveyed by visual censuses (e.g. Wickett and Corkum 1998; Ray and Corkum 2001; Johnson *et al*. 2005; Sapota and Skóra 2005), and unless surveys utilising such methods are undertaken, cryptic species may remain undetected. As fish of varying size-classes were observed, it is likely that *A. pflaumii* has occurred in southwestern Australia for at least a few years prior to the initial discovery in 2004.

No deleterious environmental impacts have been attributed to *A. pflaumii* upon introduction, though reported nonindigenous populations are quite recent (i.e. within the last decade). In Japan, *A. pflaumii* consumes benthic invertebrates (Horinouchi and Sano 2001), and Kanou *et al*. (2004) noted a trophic guild comprising *A. pflaumii* and sympatric gobiids including *Acanthogobius* spp., *Gymnogobius* spp. and *Tridentiger obscurus*. Thus, the potential exists for resource competition to occur with endemic gobiids and other ichthyofauna. The observation of *A. pflaumii* at multiple, disparate sites within southwestern Australia suggest that it has successfully colonised this region and further range expansions are likely. The fact that after discovery in the Victorian Docklands *A. pflaumii* proved to be one of the most common fishes in Port Phillip Bay is indicative of its ability to thrive in suitable habitats. Therefore, if introduced, *A. pflaumii* may colonise coastal embayments and lower estuaries along the temperate Australian coastline.

Acknowledgements

Thanks to Barry Hutchins (Western Australian Museum) and Doug Hoese (Australian Museum) for assistance identifying *A. pflaumii*.

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